Collaborative Diabetes Management in China: A Digital Empowerment Perspective

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Abstract

With the widespread of information and communication technologies (ICT) tools, home-based diabetes management (HDM) emerges as a widely approved paradigm. While extant studies focus on the enabling outcomes of ICT tools and patients' activities, this work complements extant work with the enabling mechanisms and collaborative activities among patient, doctors, and relatives. By interpreting a successful HDM project in China from the digital empowerment perspective, this work finds that all actors benefit from (1)structural empowerment since HDM bridges critical actors by building channels for blood glucose data transmission and easy communication, (2) resource empowerment since patients and relatives get more knowledge and information about diabetes management, doctors get more financial incentives, and (3) psychological empowerment since HDM strengthens critical actors' confidence, trust, and willingness to collaborate on diabetes management. The findings reveal the underlying mechanisms through which ICT tools enable HDM.

1. Introduction

The prevalence of diabetes in China is growing, which has far-reaching implications for population health status and healthcare costs. In 2017, there are 114 million people suffered from diabetes in China, accounting for 8.2 percent of the country's population and 26.82 percent of the global diabetes population. Along with the growth of diabetics comes with the increasing medical expenditure. According to the International Diabetes Federation (IDF), the annual expenditure on diabetes in China has reached 110 billion dollars in 2017, doubling that in 2016 [1]. The shortage and unevenly distribution of medical resource in China have made the situation even worse [2]. Diabetics lack convenient medical information and persistent care, and doctors are under pressure to manage large panels of patients. As a result, more effective methods for diabetes management in China are needed.

With the widespread of ICT tools, home-based diabetes management (HDM), where diabetics at home can be continuously supported remotely by doctors and patients' relatives via a series of ICT tools, emerge as a widely approved paradigm in many developing regions. Many healthcare system constraints in developing regions, such as limited medical resource, high burden of disease, high population growth, and difficulties in extending healthcare to hard-to-reach populations [2][3] can be addressed by leveraging HDM. In HDM, ICT tools enable connectivity among patients, doctors and patients' relatives and support their collaboration on patients' health management [4]. In this collaborative management paradigm, patients are their own caregivers, doctors are their consultants, and relatives are companions [5].

Extant studies have proved the positive impacts of ICT-enabled collaborative diabetes management based on a large number of randomized controlled trials. These positive impacts include the improvement of patients' adherence and health outcomes [6][7]. In developing regions that are confronted with limited medical resource, ICT-enabled collaborative management is believed to offer patients easier access to medical information and bring favorable management effects [8][9]. However, the processes through which these outcomes take place are largely lacking [10].

Several studies have explored the influencing mechanism of HDM on patients' self-management. For example, Ojo et al. put forward that the collaborative management system enables primary task support, dialogue support, and social support from doctors and relatives to enhance the persuasiveness of the medical messages and assist the self-care efforts of patients [11]. Dadgar & Joshi propose that system features,

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including connectivity, data analysis, data retrieval and data storage, afford patients' abilities to self-management by influencing patients' values [12]. However, previous studies emphasize how collaborations based on ICT tools support patient's self-management [13], less attention has been paid to the mechanisms through which ICT tools supports collaborations among critical participants, leaving the collaborative mechanisms between the critical roles unexplored.

Instead of focusing on the ICT enabling outcomes from the patients' perspective alone, this work aims to uncover the ICT enabling processes including perspectives both from the patients and their supporting participants like doctors and relatives. Therefore, we ask the following research question:

Through what mechanisms do ICT tools enable the collaboration among patients, doctors, and relatives in the HDM paradigm?

To answer this question, we draw on the theoretical perspective of digital empowerment and conduct a case study on a successful HDM project in Changzhou, Jiangsu province, China. We elaborate how the ICT tools, consisting of mobile phones, intelligent glucometer devices, and cloud platforms, improve the collaboration among patients, doctors, and relatives through structural, resource, and psychological empowerment mechanisms.

In the following sections, we first put forward an initial framework based on the diabetes management and the digital empowerment literature. Then, we present the data collection and analysis method. Next, we describe the collaborative activities brought about by ICT tools for each of the three actors in HDM. Finally, we discuss the theoretical and practical implications based on our main findings.

2. Literature review

2.1. Diabetes management

As a common chronic disease, diabetes usually cannot be cured, but it can be controlled to avoid deterioration. In the chronic disease management literature, patients' self-management of physical and psychosocial conditions, as well as their own lifestyles is a proven way for controlling diabetes [12][13].

However, implementing effective self-management is usually difficult for most diabetics [14][15]. First, patients have no access to a professional, customized, and continuously adjusted self-management plan. Second, there is a lack of supervision and guidance when special situations occur. Third, maintaining a healthy diet demands great persistence. Moreover, most diabetics are elder people who are relatively weak in learning new knowledge or getting rid of their long-standing habits.

With the rapid development and widespread of ICT tools, several ICT-enabled patients' self-management programs were suggested to overcome the difficulties mentioned above. For example, Tang et al. find that patients achieve clinically meaningful improvement of self-management in an HDM program supported by home glucometer data uploading, diabetes summary reports, and online messaging with the patient's health team [6]. Hsu et al. demonstrate that ICT tools could be effective in sharing data, enhancing communication, and improving glycemic control while enabling collaborative decision making in diabetes care [7].

Despite insightful, extant research on ICT-enabled patients' self-management programs is still inadequate in terms of the following two aspects. First, the majority report positive impacts of ICT tools on diabetes management, but the processes through which ICT tools generate these outcomes are still unclear [13]. Second, although the majority mentions doctors or relatives as important participants of self-management, it is unclear how ICT empower them to support patients' self-management of diabetes.

While some researchers indicate patients to collaborate with doctors in drawing up self-management plans and goals (such as [16][17]). More researchers suggest to also incorporate immediate family members since they complement doctors to supervise and guide patents' self-management (such as [18][19]). Therefore, this work focuses on the HDM program enabled by ICT tools, where patients, doctors, and relatives form "collaborative care" to overcome the difficulties of self-management. To address the limitations, we employ digital empowerment as our theoretical perspective, which is elaborated in the following section.

2.2. A digital empowerment perspective

Gutschoven & van den Bulck (2006) define empowerment as "an individual trait, characterized by an emphasis on increased individual control over the different aspects of one's life" on the individual level ([20] p.5). Empowerment can be considered as a process of helping people assert control over the factors which affect their lives, or the consequences of empowering processes [21].

Digital empowerment emphasizes the enabling roles of ICT tools. Extant work suggests structural, resource and psychological empowerment as three key dimensions [22][23]. Structural empowerment focuses on improving the objective external conditions (such as organizational, institutional, social, economic, political,

and cultural conditions) to offer the power to take actions [24]. Resource empowerment focuses on improving the competence and ability of the powerless in acquiring, controlling, and managing resources [25]. Psychological empowerment focuses on improving social psychology and intrinsic motivation, or on individuals' subjective interpretations (e.g., self-confidence, self-awareness, assertiveness) so that they feel in control of their own destiny [26].

Digital empowerment also takes place in the healthcare context. Several studies have discussed the empowering role of ICT tools with special attention to patients [27][28]. There are also a few studies noticing the empowerment of ICT for other critical actors. For example, some ICT tools empower doctors by assisting medical diagnosis [29], some ICT tools empower relatives with health information about their loved ones [30]. However, extant studies fail to consider all three types of empowerment for the three actors in diabetes management [31]. As a result, it is still unclear how ICT-enabled HDM empower key participants, including patients, doctors, and relatives, to better collaborate in patients' diabetes management.

To guide our data analysis, we proposed an initial research framework based on the digital empowerment perspective, as is shown in Figure 1. The basic idea of this framework is that ICT tools consisting of smart phones, intelligent glucometer, and a cloud platform, enable the collaboration among patients, doctors, and relatives in an HDM program by providing structural, resource, and psychological empowerment. These empowerment mechanisms help critical actors assert control over the factors which affect their collaboration on patients' diabetes management.

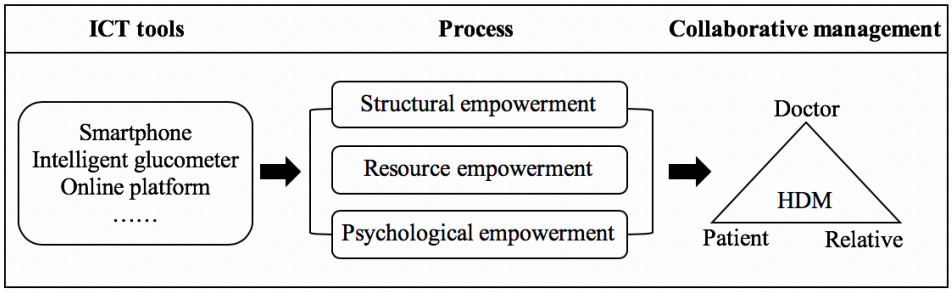

Figure 1. Analytical framework

3. Research design

3.1. Methods

We employ the case study research methodology to answer the research question since we are exploring a new phenomenon with little mature theory and the selected project is representative and revelatory [32].

The HDM project in Changzhou, Jiangsu province, China is selected as the case study target for two reasons. First, the project has been one of the earliest and most successful projects among other diabetes management trials [34]. This project was initiated by Changzhou municipal government collaborating with a medical company named Juding in September 2017. This project has achieved satisfying comments from both patients and doctors after one-year operation. Therefore, it represents the successful practice of HDM. Second, the research team has good access to the main participants of this project, which ensures the accessibility of data.

3.2. Data collection

This research collected abundant primary and secondary data to comprehensively and objectively describe the implementation of HDM.

Primary data are mainly obtained through interviews. The research team conducted one-on-one interviews with 7 doctors (DO), 3 patients (PA), 2 patients' relatives (PR) involved in the HDM project. The interview outline for doctors, patients and relatives includes: The start time and the motivation of participating in HDM; The service process in HDM; The communication experience with other actors; The use experience of HDM and suggestions for improvement.

Secondary data mainly includes the official website of Juding, news reports on "chronic disease management" "diabetes management", relevant industry information reports and academic journals in Chinese and English. The second-hand data collected in this paper are mainly used to reverify the accuracy and reliability of interview data. The use of data follows the triangulation principle of researchers and data sources to ensure the reliability and validity of data analysis [33].

3.3. Data analysis

We began analyzing data as we collected it. The data analysis starts from the observation of the outcomes of empowerment in HDM, then we interpret the empowerment process which leads to these outcomes. Collaborative diabetes management requires each critical actor's active involvement in its own management actions, as well as communication and cooperation with other actors. Therefore, this study analyzes the collaboration processes in HDM from each actor's perspective. Next, we will take the patient's perspective as an example to elaborate the data analysis process.

The empowerment perspective sensitized us to the related information of the outcomes of empowerment in HDM. First, we recorded the narratives reflecting patients' management activities in the offline context and the HDM context in tabular form. An example is shown in table 1. Second, we summarized the changes from offline to HDM context caused by digital empowerment through coding these narratives. Third, based on this summary, we highlighted descriptions related to structural, resource and psychological empowerment process. From the descriptions, we identified tentative explanations that depicted the practice of patients in using HDM to collaborate with other actors and gain control of self-management. Forth, we focused on the further "abstraction" of the tentative explanations to summarize the content of three types of empowerment for patients, and consider the relationships between different dimensions of empowerment process to depict the complete picture of empowerment enabled by HDM. We did this independently for each critical actor in HDM.

Table 1. Patients' management activities in the offline context and the HDM context

Offline context	HDM context
Blood glucose measurement	
1. I did not pay much attention to checking blood glucose before, because no one reminded me of it. I checked my blood glucose level less than once a month when I was busy. (PA2) **[Frequency: Low, Supervision: Low, Self-awareness: Low]** 2. I go to the hospital to check blood glucose about once a week. (PA2) **[Time-consuming, Frequency: Low]**	1. I check patients' blood glucose level every day, and I will remind patients who don't upload their blood glucose. (DO4) **[Supervision: High]** 2. I measure blood glucose 2 to 3 times a day during this period. (PA2) [**Frequency: High**] 3. With the blood glucose meter, I can measure blood glucose myself and send the result to the doctor. This is convenient. (PA1) **[Time-saving, Self-awareness: High]**

4. Case analysis

4.1. Case description

This study shows the HDM mode in Changzhou in figure 2. In HDM, critical actors include patients, doctors and relatives. There are three kinds of IT tools, the portable intelligent glucometer, the diabetes management cloud platform and the mobile work platform based on WeChat application (Wechat is an instant messaging software in China).

The service process of HDM is described as follows. First, patients and doctors complete the contract offline, and an intelligent glucometer will be given to the contracted patient to support the blood glucose measuring at home. At the same time, several relatives are bound with the patient to participate in HDM. Second, patients measure blood glucose at home, and the result will be uploaded to the diabetes management cloud platform to form long-term blood glucose reports. The reports will be synchronized to patients, relatives and doctors through Wechat. Third, doctors, patients and relatives can communicate at any time based on mobile work platforms. If an abnormal glucose situation is detected, the cloud platform will immediately send an alert to doctors, patients and patients' relatives.

In order to promote the HDM project, Juding provides free trials for patients for one month. After one month, the hospital will charge patients who continue to use the service 2.5 yuan per day. Most of these fees are returned to the doctor.

In Sections 4.2 to 4.4, we summarize the differences of the collaborative management activities for each actor in the offline context and the HDM context. Based on these outcomes of empowerment in HDM, we explain the empowerment process from structural, resource and psychological perspectives.

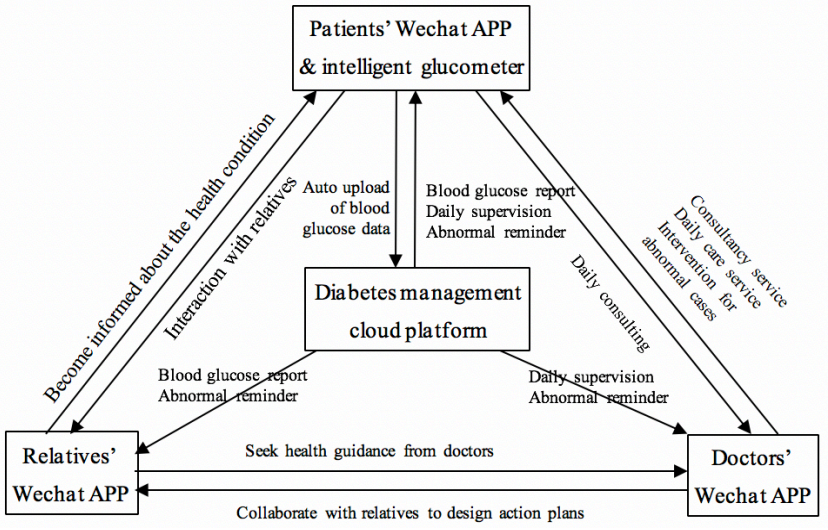

Figure 2. The HDM mode

4.2. Digital empowerment for patient in HDM

Patients' collaborative management activities in HDM consist of blood glucose measurement, doctor-patient communication, and health awareness and lifestyle management. The summary of the comparison of these activities in the offline context and HDM context are shown in the left side of table 2. Specifically, in HDM, blood glucose measurement for patients becomes more convenient and more frequent under the supervision of doctors. Frequent, long-term communication is established between patients and doctors. In the communication, doctors pay more attention to the suggestions on patients' lifestyle and emotional encouragement, and patients' trust on doctors improves. In terms of patients' health awareness and lifestyle management, with the assistance of doctors, patients' subjective initiative is improved.

Further, we analyze how HDM empowers patients to support patient-centered collaboration according to the definitions of structural, resource and psychological empowerment, as shown in the right side of table 2.

From structural empowerment's perspective, HDM enables convenient glucose data transmission and information exchange between patients and doctors. Offline, patients need to take the initiative to measure blood glucose and communicate with doctors in hospitals. Tedious and time-consuming offline medical treatment leads to the infrequent blood glucose measurement, and infrequent doctor-patient interaction. HDM breaks the constraints of the exchange of blood glucose data and health information between patients and doctors. Data synchronization guides patients to conduct blood glucose measurement more frequently, and patients can seek information from doctors more actively and conveniently.

From resource empowerment's perspective, HDM relieves patients' helplessness in diabetes management by offering patients more informational support. In the traditional blood glucose management, the patients' self-management faces several difficulties. First, patients lack of overall understanding of their physical conditions. Second, patients lack sufficient health knowledge to support their independent and correct diabetes management. Finally, it is difficult for patients to find the changes of blood glucose data derived from the management of daily life [14][15]. As a result of structural empowerment in the HDM, patients acquire more informational support. On the one hand, patients enhance their understanding of their blood glucose situations through the functions of long-term blood glucose reports, data monitoring and early warning of abnormal cases provided by the diabetes management cloud platform. On the other hand, doctors provide professional guidance, timely and personalized feedbacks to patients, which assist patients in self-management and dealing with abnormal conditions.

From psychological empowerment's perspective, HDM strengthens patients' belief and confidence in self-management by persistent monitoring and the emotional support from doctors. As a result of resource empowerment, the improvement of patients' capacity for self-management relieves patients' helplessness in dealing with health-related issues. Also, more frequent doctor-patient communication allows for more emotional support from doctors, which motivates patients to take better control of glucose level. Changing patients' psychological state from passive coordinate to active participation, HDM promotes patients' self-efficiency in diabetes management.

Table 2. Digital empowerment for patient-centered collaboration in HDM

Dimensions	Offline context	HDM context	The digital empowerment mechanisms
Blood glucose measurement			**Structural empowerment** 1. HDM enables convenient glucose data transmission between doctors and patients. 2. HDM lowers the threshold for patients to get in touch with doctors. **Resource empowerment** 1. HDM provides patient with systematic glucose data reports, continuous monitoring and timely warning 2. HDM provides patients with timely, personalized, and detailed feedbacks from doctors **Psychological empowerment** 1. HDM strengthens patients' belief and confidence in self-management by providing persistent supervision and emotional support from doctors
Duration	Time-consuming	Time-saving	
Frequency	Low	High	
Self-awareness	Low	High	
Supervision	Weak	Strong	
Doctor-patient communication			
Corresponding doctors	Randomly assigned	Contracted doctor	
Duration	Short	Long or short	
Frequency	Low	High	
Dominance	Doctor-centered	Patient-centered	
Content	Treatment	Treatment, life advice, emotional support	
trust on doctors	Weak	Relatively strong	
Health awareness and lifestyle management			
Subjective initiative	Low	relatively high	
Management style	Patient manage independently	Doctor assist patient	
Treatment	General advice	Personalized, detailed	
Feedback	one-time feedback	Periodical feedback	

4.3. Digital empowerment for doctor in HDM

According to the interviews with doctors, this study finds that for doctors, blood glucose monitoring, blood glucose regulation, doctor-patient communication and income in HDM have changed compared to offline. The comparison of these activities in different situations are summarized in the left side of table 3. Specifically, in HDM, the aid of ICT tools makes the blood glucose monitoring more direct and convenient for doctors. Due to continuous monitoring and management, doctors are more inclined to intervene blood glucose by adjusting daily life with the cooperation of relatives instead of using drugs and hospitalization. Doctor-patient communication becomes more frequent and concise, which strengthens doctor-patient relationship and improves the communication efficiency. Finally, HDM brings additional income to doctors, which is the main motivation for many doctors to participate in HDM.

Further, we analyze how HDM empowers doctors to support doctor-centered collaboration according to the definitions of structural, resource and psychological empowerment, as shown in the right side of table 3.

From structural empowerment's perspective, HDM reduces doctors' workload by supporting data transmission and convenient communication among doctors, patients and relatives remotely. From offline to mobile situation, doctors acquire patients' blood glucose data from offline measurement to online synchronization, and the communication between doctors and patients changes from infrequent, deep communication to frequent, concise communication. HDM simplifies the consultation process and reduces communication costs. Doctors do not need to reply to patients every time if patients' glucose is normal. Only when abnormal conditions occur do doctors need to give timely feedbacks to patients, which improves the freedom and convenience of doctors' feedback. Communication between doctors and relatives also reduces communication costs for doctors.

Resource empowerment for doctors has binary aspects. As a result of structural empowerment, doctors gain support from ICT tools and build relationship with more patients. The advantages of HDM in blood glucose data integration, analysis assists doctors' understanding and comprehensive judgments about patients' physical conditions. Real-time monitoring and early warnings improve doctors' ability to respond. Besides, reduced workload and improved work efficiency allows for more clients, and thus more extra

economic returns for doctors, which further simulates doctors' working enthusiasm.

More responsibilities and emotional connections between doctors and patients induce doctors' intrinsic intention to take more active parts in patients' diabetes management, which is the process of psychological empowerment for doctors. In traditional diabetes management, doctors have no access to patients' situations unless patients take the initiative to communicate with doctor. Doctors usually feel no responsibility for patients beyond their control. Based on structural empowerment and resource empowerment, HDM breaks the limitations of doctor-patient communication scenarios, and improves doctors' ability to manage patients, which encourages doctors to take more responsibility for patients' diabetes management. Besides, long-term doctor-patient communication strengthens the emotional connections between doctors and patients. The establishment of doctor-patient relationship makes doctors willing to make more contributions to protect patients' health.

Table 3. Digital empowerment for doctor-centered collaboration in HDM

Dimensions	Offline context	HDM context	The digital empowerment mechanisms
Blood glucose monitoring			**Structural empowerment** 1. HDM reduces doctors' workload by supporting data transmission and convenient communication among doctors, patients and relatives remotely. **Resource empowerment** 1. Data integration, data analysis, and real-time data monitoring provided by HDM improves doctors' work efficiency 2. HDM increases doctors' legitimate income and thus stimulates doctors' working enthusiasm **Psychological empowerment** 1. HDM urges doctors to take more responsibility in patients' diabetes management by breaking the limitations of doctor-patient communication scenarios and improving doctors' ability. 2. The establish of doctor-patient relationship urges doctors to take more active parts in patients' diabetes management
difficulty	high	Low	
Regulator	Doctors	Doctors assisted by ICT	
Frequency	Low	High	
Data records	Scattered or none	Systematic and periodical report	
Early warning	None	warning when abnormity is detected	
Blood glucose regulation			
Regulator	Doctors alone	Doctor work with patients and relatives	
Emphasis	Abnormal situation	Daily life	
Therapeutic regimen	Drug therapy	Adjust daily lifestyle	
Doctor-patient communication			
Frequency	Low	High	
Efficiency	Low	High	
Content	Treatment	Treatment, life advice, encourage	
Patient's compliance	Low	High	
Income			
Income	Fixed salary	Extra income	
Feedback	one-time feedback	Periodical feedback	

4.4. Digital empowerment for relative in HDM

Relatives participate in collaborative diabetes management through monitoring patients' blood glucose, communicating with doctors and supporting patients' self-management in daily life. The comparison of these activities in different situations are summarized in the left side of table 4. Specifically, in HDM, relatives get easier access to patients' blood glucose measurement records. The communication with doctors becomes more frequent and convenient. Relatives supports patients' self-management with doctors' professional guidance.

Further, we analyze how HDM empowers relatives to support relative-centered collaboration according to the definitions of structural, resource and psychological empowerment, as shown in the right side of table 4.

From structural empowerment's perspective, HDM lowers the hindrance of relatives' participation. The main obstacles for relatives to participate in patients' diabetes management have two aspects. First is the lack of direct access to the patients' blood glucose data, and second is the inability to maintain communication with doctors. HDM breaks these limitations by

affording channels of monitoring patients' glucose data and communicating with doctors.

From resource empowerment's perspective, HDM enhances relatives' competence of participating in collaborative management by providing more information resource. In diabetes management, relatives are not direct participants. Compared with patients and doctors, relatives lack experience and medical knowledge. Therefore, medical knowledge is critical for relatives' management activities. As a result of structural empowerment, relatives gain better understanding of patients' physical conditions through systematic report on glucose data, continuous monitoring and timely warning. More frequent communication between relatives and doctors assists relatives to intervene patients' blood glucose with doctors' professional guidance.

From psychological empowerment's perspective, as a result of resource empowerment, relatives gain more information and professional guidance, which motivates them take more responsibilities to collaborate with doctors to ensure that doctors' suggestions on diabetes management are implemented in patients' daily life.

Table 4. Digital empowerment for relative-centered collaboration in HDM

Dimensions	Offline context	HDM context
Blood glucose monitoring		
Frequency	Low	High
Difficulty	High	Low
Understanding level	Low	High
Communication with doctors		
Threshold	High	Low
Frequency	Low	Improved
Diabetes self-management supporting		
Knowledge source	Manage patient based on their own knowledge	Manage patient based on doctor's guidance

Structural empowerment
1. HDM lowers the hindrance of relatives' participation.

Resource empowerment
1. HDM enhances relatives' understanding of patients' physical conditions by providing systematic report on glucose data, continuous monitoring and timely warning.
2. HDM enables relatives to better support patients' daily life according to doctors' personalized guidance.

Psychological empowerment
1. HDM motivates relatives to collaborate with doctors and support patients' self-management by improving relatives' competence.

5. Conclusions and Implications

5.1. Conclusions

This study explores the mechanisms through which ICT tools realize the collaboration among patients, doctors, and relatives in HDM from the perspective of digital empowerment. According to our case study on a successful HDM project in China, we summarize our findings in the following.

First, HDM supports critical actors' collaborative diabetes management though structural, resource and psychological empowerment processes. In particular,

all critical actors benefit from structural empowerment since HDM bridges critical actors by building channels for blood glucose data transmission and easy communication. In terms of resource empowerment, HDM enables accurate, immediate, and continuous updates of patients' health conditions. Besides, while patients and relatives get more knowledge of diabetes management from doctors, doctors gain more financial incentives. In terms of psychological empowerment, HDM strengthens critical actors' confidence, trust, and willingness to collaborate on diabetes management.

Second, we summarize the inner links between different dimensions of digital empowerment in HDM. Structural empowerment is the basis for realizing the other two types of digital empowerment. Based on the connections among critical actors and the management platform, more information and resource flow in the network, which supports resource empowerment. Further, structural empowerment and resource empowerment induce critical actors' psychological empowerment. Closer relationships among critical actors, and improved competence derived from the increase of resource strengthen critical actors' confidence and willingness to collaborate on diabetes management.

5.2. Implications

Our research offers three key theoretical contributions. First, this research investigates the effects of HDM by considering patients', doctors' and relatives' management activities in HDM, which complements previous studies by providing more comprehensive perspectives. Second, previous

studies mainly focus on the effects of collaborations among critical actors based on ICT tools on patient's self-management [13][14]. While this study probes into how ICT supports collaborations to explore the process through which the positive effects take place. Third, previous studies describe the empowerment in chronic disease management only based on single actor and single dimension [28][30]. By contrast, this research puts forward an innovative analytical framework for chronic disease management through examining three dimensions of digital empowerment from each critical actor's perspective in HDM.

This study generates practical insights by dissecting the application and implementation process of a representative HDM project in China, which provides references for many other developing regions to conduct ICT-based diabetes management. HDM is effective in diabetes management for developing regions by addressing healthcare system constraints [3]. However, how to keep critical actors motivated and engaged in HDM and build collaboration needs to be further explained. Our work informs health policies on empowering and engaging patients, doctors and relatives in collaborative diabetes management rather than only highlighting patients' self-management in diabetes management with the use of ICTs. Besides, more actions can be taken to facilitate the collaborative diabetes management from the perspective of empowerment. For example, strengthening the construction of medical ICT tools to bridging the information and resource exchange among critical actors, establishing reasonable incentive mechanisms for doctors, such as extra income. In addition to health education for patients, focusing on the improvement of relatives' management competence is also conducive to effective diabetes management.

5.3. Limitations and future research

This research has some limitations. Doctors can be further divided into two types, specialist physicians and community doctors. They take different responsibilities in chronic disease management. We didn't clarify the different roles of the doctors in this work. Future studies are encouraged to consider the collaboration between specialist physicians and community doctors. Besides, this work accesses the outcomes of HDM implementation by investigating the use experience of critical actors, which is subjective and qualitative. We suggest future work to combine objective glucose data with subjective perceptions for participants to access the outcomes of HDM.

6. Acknowledge

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7. References

[1] International Diabetes Federation. IDF diabetes atlas. 8th, 2017, Available at https://diabetesatlas.org/resources/2017-atlas.html

[2] H. S. Kim, C. Sun, S. J. Yang, et al., "Randomized, open-label, parallel group study to evaluate the effect of internet-based glucose management system on subjects with diabetes in China", Telemedicine and e-Health, 22(8), 2016, pp. 666-674.

[3] A. Beratarrechea, A. G. Lee, J. M. Willner, et al., "The impact of mobile health interventions on chronic disease outcomes in developing countries: a systematic review", Telemedicine and e-Health, 20(1), 2014, pp. 75-82.

[4] B. B. Green, A. J. Cook, J. D. Ralston, et al., "Effectiveness of Home Blood Pressure Monitoring, Web Communication, and Pharmacist Care on Hypertension Control: A Randomized Controlled Trial", The Journal of the American Medical Association, 299(24), 2008, pp. 2857-2867.

[5] P. Khosravi, and A. H. Ghapanchi, "Investigating the Effectiveness of Technologies Applied to Assist Seniors: A Systematic Literature Review", International journal of medical informatics, 85(1), 2016, pp. 17-26.

[6] P. C. Tang, J. M. Overhage, A. S. Chan, et al., "Online Disease Management of Diabetes: Engaging and Motivating Patients Online with Enhanced Resources-Diabetes (Empower-D), a Randomized Controlled Trial", Journal of the American Medical Informatics Association, 20(3), 2012, pp. 526-534.

[7] W.C. Hsu, K. H. K. Lau, R. Huang, et al., "Utilization of a cloud-based diabetes management program for insulin initiation and titration enables collaborative decision making between healthcare providers and patients", Diabetes technology & therapeutics, 18(2), 2016, pp. 59-67.

[8] J. K. Liou, M. S. Soon, C. H. Chen, et al., "Shared Care Combined with Telecare Improves Glycemic Control of Diabetic Patients in a Rural Underserved Community", Telemedicine and e-Health, 20(2), 2014, pp. 175-178.

[9] F. Yasmin, B. Banu, S. M. Zakir, et al., "Positive influence of short message service and voice call interventions on adherence and health outcomes in case of chronic disease care: a systematic review", BMC medical informatics and decision making, 16(1), 2016, pp. 46.

[10] K. Kroenke, E. E. Krebs, J. Wu, et al., “Telecare collaborative management of chronic pain in primary care: a randomized clinical trial”, Jama, 312(3), 2014, pp.240.

[11] A. Ojo, S. Chatterjee, H. W. Neighbors, et al. 2015. “Oh-Buddy: Mobile Phone Texting Based Intervention for Diabetes and Oral Health Management”, 2015 48th Hawaii International Conference on System Sciences: IEEE, pp. 803-813.

[12] M. Dadgar, and K. D. Joshi, “The Role of Information and Communication Technology in Self-Management of Chronic Diseases: An Empirical Investigation through Value Sensitive Design”, Journal of the Association for Information Systems, 19(2), 2018, pp. 86-112.

[13] M. S. McDermott, A. E. J. P. E. While, and Counseling, “Maximizing the Healthcare Environment: A Systematic Review Exploring the Potential of Computer Technology to Promote Self-Management of Chronic Illness in Healthcare Settings”, Patient education and counseling, 92(1), 2013, pp. 13-22.

[14] F. Jerant, M. M. von Friederichs-Fitzwater, & M. Moore, “Patients’ perceived barriers to active self-management of chronic conditions”, Patient education and counseling, 57(3), 2005, pp. 300-307.

[15] J. Ahola, & P. H. Groop, “Barriers to self-management of diabetes”, Diabetic Medicine, 30(4), 2013, pp. 413-420.

[16] N. Archer, K. Keshavjee, C. Demers, et al., “Online Self-Management Interventions for Chronically Ill Patients: Cognitive Impairment and Technology Issues”, International Journal of Medical Informatics, 83(4), 2014, pp. 264-272.

[17] L. M. Mackey, C. Doody, E. L. Werner, et al., “Self-Management Skills in Chronic Disease Management: What Role Does Health Literacy Have?”, Medical Decision Making, 36(6), 2016, pp. 741-759.

[18] P. Ryan, and K. J. J. N. o. Sawin, “The Individual and Family Self-Management Theory: Background and Perspectives on Context, Process, and Outcomes”, Nursing outlook, 57(4), 2009, pp. 217-225. e216.

[19] A. Dirik, S. Sandhu, D. Giacco, et al., “Why involve families in acute mental healthcare? A collaborative conceptual review”, BMJ open, 7(9), 2017, pp. e017680.

[20] K. Gutschoven, and J. Van den Bulck. 2006. “Towards the Measurement of Psychological Health Empowerment in the General Public," annual meeting of the International Communication Association, Dresden International Congress Centre, Dresden, Germany.

[21] D. D. Perkins, and M. A. Zimmerman, “Empowerment Theory, Research, and Application”, American Journal of Community Psychology, 23(5), 1995, pp. 569-579.

[22] C. M. L. Leong, S. L. Pan, P. Ractham, et al., “ICT-Enabled Community Empowerment in Crisis Response: Social Media in Thailand Flooding 2011”, Journal of the Association for Information Systems, 16(3), 2015, pp. 1.

[23] Q. Sun, C. Wang, L.S. Zuo, et al., "Digital Empowerment in a WEEE Collection Business Ecosystem: A Comparative Study of Two Typical Cases in China”, Journal of cleaner production, 184, 2018, pp. 414-422.

[24] N. D. Lincoln, C. Travers, P. Ackers, et al., “The meaning of empowerment: The interdisciplinary etymology of a new management concept”, International Journal of Management Reviews, 4(3), 2002, pp. 271–290.

[25] C. Hardy, and S. Leiba-O'Sullivan, “The Power Behind Empowerment: Implications for Research and Practice”, Human Relations, 51(4), 1998, pp. 451-483.

[26] B. D. Christens, “Toward relational empowerment”, American Journal of Community Psychology, 50(1), 2012, pp. 114 - 128.

[27] P. Hanlon, L. Daines, C. Campbell, et al., “Telehealth Interventions to Support Self-Management of Long-Term Conditions: A Systematic Metareview of Diabetes, Heart Failure, Asthma, Chronic Obstructive Pulmonary Disease, and Cancer”, Journal of medical Internet research, 19(5), 2017, pp. e172.

[28] W. Kuijpers, W. G. Groen, N. K. Aaronson, et al., “A Systematic Review of Web-Based Interventions for Patient Empowerment and Physical Activity in Chronic Diseases: Relevance for Cancer Survivors”, Journal of medical Internet research, 15(2), 2013, pp. e37.

[29] M. Bsoul, H. Minn, and L. Tamil, “Apnea Medassist: Nonnecke. Real-time sleep apnea monitor using single-lead EEG”, IEEE Trans Inf Technol Biomed, 5(3), 2011 May, 1, pp. 416–427.

[30] M. W. Zhang, and R. C. Ho. 2017. “M-Health and Smartphone Technologies and Their Impact on Patient Care and Empowerment," in The Digitization of Healthcare. Springer, pp. 277-291.

[31] M. H. Hur, “Empowerment in terms of theoretical perspectives: Exploring a typology of the process and components across disciplines”, Journal of Community Psychology, 34(5), 2006, pp. 523-540.

[32] G. Walsham, “Doing interpretive research”, European Journal of Information Systems, 15(3), 2006, pp. 320-330.

[33] R. K. Yin, “Case Study Research: Design and Methods. Thousand Oaks”, CA: Sage Publications, 2003.

[34] K. M. Eisenhardt, & M. E. Graebner, “Theory Building from Cases: Opportunities and Challenges”, Academy of Management Journal, 50(1), 2007, pp.25-62.